harvest (fig. 15, reproduced in fig. 2) were used with a new set of dates to make a map of the advance of autumn. Local modifications were necessary to allow for the effects of the Great Lakes and Atlantic Ocean. Such a map may be used as a general basis for "safe" wheat seeding, because the development of the Hessian fly is closely dependent on late-summer and autumn weather.

The lines were dated and modified in "an attempt to correlate the recommendations of the different experiment stations as to the date of seeding winter wheat. The results of experiments in Kansas, Nebraska, Iowa, Indiana, and Ohio show that when the Hessian fly is prevalent the best yields may be expected when the seeding occurs just after the emergence of the last autumn brood of the fly; and when the fly is not numerous, the best time for seeding generally is about a week earlier. In the years when the fly is prevalent the actual dates to be recommended depend on experiments in the fields at the time, so in such years it is necessary to follow closely the recommendations of the State entomologists. Planting in the North depends largely on the season and the labor situation. South of the thirty-ninth parallel and east of southeastern Kansas the autumn is long enough to allow seeding after the average date of emergence of the fly, with the best chance of still securing the maximum yield." The altitude-latitude table inserted in the map represents the reverse of the latitude and altitude rate of progress of winter-wheat harvest, which progresses about a degree of latitude or 400 feet of general altitude in 4 days.

As Dr. Hopkins points out, there are many other ways in which the maps showing the actual dates of operations can be used as a basis for improving farm practice and for determining the best regions for expanding the average of different crops.

Supplementing these isochronal maps, are 17 "dot" maps showing the acreage distribution of the crops mentioned. Two maps show the regions where corn is cut and shocked, and where corn is jerked from standing stalks. Two graphs show the production of early and of late potatoes by date of harvest zones. The applications to farm management and farm labor problems are brought out in detail by graphs showing the hours devoted to different farm operations by 10-day periods throughout the year at seven typical farming regions of the United States. There are three large dot maps showing the distribution of farmers, of farm laborers, and of expenditure for labor.—*C. F. Brooks.*

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## DUFRÊNOY'S OBSERVATIONS OF THE TEMPERATURES OF PLANTS IN SUNLIGHT AND SHADE.

The difference in the temperature of plants in direct sunshine and in shade, and the action of the pigments in varying the temperature of different colored leaves and plants in sunshine, is shown in a recent article by the French naturalist Mr. J. Dufrénoy, of the biological station at Arachon, in the Revue Générale de Sciences.

He explains the formation of the pigments in plants, and the increase or decrease of pigmentation with varying heat, moisture, and sunshine values, then shows the effect of these different pigments in the absorption of solar energy.

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We quote the following from a recent review of this article in the Scientific American Supplement for February 15, 1919:

* * * The solar energy absorbed by the pigments is largely converted into heat. In January at Arachon, on a fine day, the temperature of the plants exposed to the sun exceeds that of the air by from 6° to 8° C. at noon, and by from 12° to 15° C. at 3 p. m.; the amount of this rise in temperature varies according to the color and to the intensity of the pigmentation, so that a difference of more than 1° C. may exist between the yellow and the green leaves of the variegated foliage of a spindle tree, or even between the two borders of a single variegated leaf.

Experiments made in January at Arachon gave the following results: In a variegated leaf of the *Iris pallida* the green portion showed a rise in temperature of 9.8° C. over that of the air against a rise of only 8.5° C. in the yellow portion. Similar observations were made with the red and green leaves of an arbutus, the time being 10 a. m. and the temperature of the air 10° C.; in this case the red leaf showed a rise of 7.5° C. and the green leaf a rise of only 7° C.

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In November tests were made at 2 p. m. with red and white arbutus berries, the temperature of the latter being 29.5° C. and that of the red one degree higher.

Finally experiments were made with grapes of various colors placed in sunshine and in shade. The temperature of the red grapes in the sun was 37° C. and 10° C. less in the shade; that of white, green, and amber colored grapes was 34° C. in the sun, and 26° C. in the shade. The time of this last experiment was October 10, at 3 p. m., the temperature of the air being 24° C. in the shade. A second experiment showed that grapes with a dull surface had a temperature of 35.5° C. in the sun, whereas that of those with a bright surface was 34.8° C.

A highly interesting fact is that every rise of 10° C. in the temperature of the organs exposed to sunlight doubles or even trebles the rapidity of the reactions observed—for example, the intensity of respiration is greatly enhanced, more carbon dioxide being liberated.

In fruits exposed to sunlight the plant acids contained are reduced, and the ripening is correspondingly hastened. * * *

These experiments illustrate the difficulty in making comparable records of the temperature of plants in sunshine as made by different investigators, or by the same man at different times.—*J. Warren Smith.*

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## NOTE ON THE HEATING OF PLANTS IN SUNLIGHT AS A FACTOR IN GROWTH.*

By D. A. SEELEY, Meteorologist.

[Dated: Weather Bureau, Lansing, Mich., May, 1919.]

The results of M. Dufrénoy's observations on the temperature of plants, as quoted above, offer further evidence of the importance of sunshine in plant growth. Differences of 12° to 15° C. (22° to 27° F.), noted by M. Dufrénoy between leaf and air temperature on clear days, are not in excess of those observed by several other investigators at various times. Such large temperature differences must surely produce marked metabolic activities in the plant, not to mention the actinic influences. The fact that under sunshine plants are so much warmer than the air should be given more consideration in studies of the relationship between weather conditions and plant growth. In the past it has been the custom to study air temperature in relation to plant growth without considering the often widely different temperature of the plant itself, especially in sunshine. The "Summation method," by which the excess of air temperature above a given limit is computed, gives widely divergent results when worked out for a given life phase of plants in different years, largely on account of the failure to take into consideration the difference between plant and air temperature. When the sun is shining the air temperature does not register the true thermal con-

* Cf. "Crops and temperature," Abs. in Mo. WEA. REV. 1917, 45: 354-359.

dition of the plant and hence does not furnish an accurate index of growth. Cloudiness and other factors cause variations in the duration and intensity of sunshine, which are only partially reflected by the air temperature, while the plant responds more perfectly.

### MEASURING THE TEMPERATURE OF LEAVES.

Mrs. Edith B. Shreve has devised very sensitive electrical apparatus for measuring the surface temperature of leaves and has been making measurements in the desert and mountains near Tucson, Ariz., and the Santa Lucia Mountains in California. She reports that the most outstanding result of these measurements is the rapidity with which the surface temperature of a leaf growing in the open may fluctuate. Changes of from 1 to 3° C. are observed within 20 to 60 seconds. If a moderately strong wind is blowing the change may amount to 5° in 30 seconds. [Momentary changes in the temperature of the passing air are without doubt in part the cause of these fluctuations.]—*Reprinted from Scientific American, Apr. 12, 1919, p. 365.*

## ALFALFA GROWING IN WESTERN SOUTH DAKOTA.

By HARLEY N. JOHNSON.

[Dated: Weather Bureau, Rapid City, S. Dak., April, 1919.]

SYNOPSIS.—The climate of western South Dakota is especially favorable for raising alfalfa, as 73 per cent of the annual rainfall of 15 to 20 inches is received during the period from April 1 to September 30, the percentage of sunshine is high, the rate of evaporation is comparatively low, and moderate temperatures usually prevail during the growing season. The soil is deep and rich and retains moisture well. Alfalfa needs considerable moisture while growing, but fair weather while the hay crop is being harvested.

Alfalfa seed is usually produced from the second crop when conditions are such as to retard the maturing of the first hay crop. Alfalfa seed is produced in paying quantities in South Dakota only when there is a comparative shortage in the moisture supply, hence the weather conditions determine whether the second crop shall be cut for hay or left for seed. If there is considerable rainfall, the second crop is usually cut for hay, and a third crop is frequently possible.

As alfalfa hay is damaged by rain when curing, special weather forecasts are issued and widely distributed during harvest. The growing season is usually of sufficient length to mature seed from the second crop, but if it is too dry after the first crop has been harvested, and the growth of the second crop checked, there is danger of frost injury to seed in the early fall. A frost-warning service is therefore maintained and is widely utilized by seed growers.—*J. W. S.*

There are 24 counties in South Dakota west of the Missouri River, comprising 26,266,895 acres, of which, roughly 5 per cent is devoted to the raising of alfalfa. The usual yield is from two to three crops of hay per year, or approximately 3 to 5 tons per acre. Western South Dakota has been producing alfalfa for the past 38 years, the first seed of record being brought from Utah in 1881, and it is now successfully grown in every county and has become the great staple forage crop.

The experience of alfalfa growers, covering a period of a great many years, shows that a semi-arid region is particularly adapted to the raising of alfalfa. From 15 to 20 inches of annual rainfall is usually considered necessary for successful farming operations, without irrigation. However, there are several modifying factors to be taken into consideration in connection with the raising of alfalfa in a region of light rainfall, viz, the seasonal distribution of rainfall (73 per cent of the annual, falls from April to September in western South Dakota); the rate of evaporation; amount of sunshine; temperature; and the qualities of the soil for retaining moisture. The deep rich soil of the farming sections of western South Dakota, the prevalent warm sunshiny weather, and the favorable distribution of precipitation evidently produce the proper combination necessary for its best growth. There is practically no land in western South Dakota, that is susceptible of cultivation, that will not produce alfalfa, and probably 95 per cent of the production is grown without irrigation, the practice of irrigation being limited to a few valleys where the crop is grown almost exclusively for hay. (See fig. 1.)

Three varieties are most extensively grown, viz: Common or mixed varieties, Grim, and Turkestan.

The first step in the process of raising alfalfa is the preparation of the seed bed, which is of vital importance. The ground should be plowed and harrowed, or double disked, then given time (from a month to six weeks) to settle thoroughly before planting the seed. The planting is usually done in the spring, with a drill having a special feed for alfalfa, and is set to sow from 10 to 12 pounds of seed per acre, and to cover the seed from 1 to 1½ inches deep. Just before planting the top crust should be loosened and pulverized by light harrowing, as this will insure a fine soil on the surface for seeding and a firmer soil below for the embedding of of the tap root, which immediately strikes downward after germination of the seed. However, there are many fields of alfalfa where the seed was sown broadcast on unbroken sod and disked in. This method is not advisable as experience has shown that the stand will die out in a few years, although the first two or three years crop may be exceptionally good.

The alfalfa plant is more or less subject to winter-killing, a situation that is practically unpreventable, except where irrigation is practiced. The chief causes of winter killing in the Middle West are: Excessively dry weather in the late fall and winter, and alternate freezing and thawing of the soil. From the first cause the injury is frequently of considerable consequence, as occasionally the fall precipitation is insufficient to supply the soil with moisture necessary to keep the plant alive, and for evaporation. However, this feature is overcome to some extent by an average snowfall of 13.5 inches (Rapid City record) during the months of December, January, and February. The snow blanket affords a protection from the cold and wind, thus eliminating the winter-killing that would otherwise result in an open dry winter with no snow covering. From the second cause the injury is probably greater. The damage from this cause is increased when an excessive amount of precipitation occurs in the late fall. When the soil is saturated with water the alternate freezing and thawing on days when the ground is bare may prove fatal to the plant, due to the fact that the sap rises into the branches on warm days, then freezes when the temperature falls, thus causing an expansion or rupture of the cells of the plant. The average number of freezing and thawing days, with no snow covering, for the three winter months is as follows: December, 10; January, 10; February, 9.

Almost without exception the first crop of alfalfa is utilized for hay. If the season is early and the first crop of hay is matured and cut before June 10, the prospects for two more hay crops are good, but if the first